



Surface Operations Simulator and Scheduler (SOSS) Presentation

Zhifan Zhu
Stinger Ghaffarian Technology
NASA Ames Research Center

Joint Workshop for KAIA/KARI/IIAC-NASA Collaboration
Korea Aerospace Research Institute, Daejeon, Korea
Incheon International Airport, Incheon, Korea
April 5-7, 2016

Outline



- What is SOSS?
- SOSS Architecture
- How SOSS Models Airport Surface Traffic
- Build a SOSS ICN model

What is SOSS?



- Fast time simulation tool running on desktop/laptop computers

	Call Sign	AC Type	Category	P Time
1	WJY7908	A321	Departure	05815
2	FAB6269	A333	Departure	09231
3	FBY158	A321	Arrival	04692
4	FRS350	8738	Arrival	01206
5	TTS4929	8738	Departure	08560
6	CSQ57	8738	Arrival	01326
7	SSN527	A321	Departure	03036
8	ISQ88			
9	SSN62			
10	ISQ31			
11	TTS00			
12	VHR87			
13	ISQ15			
14	ZWL14			
15	FAP03			
16	ISQ14			

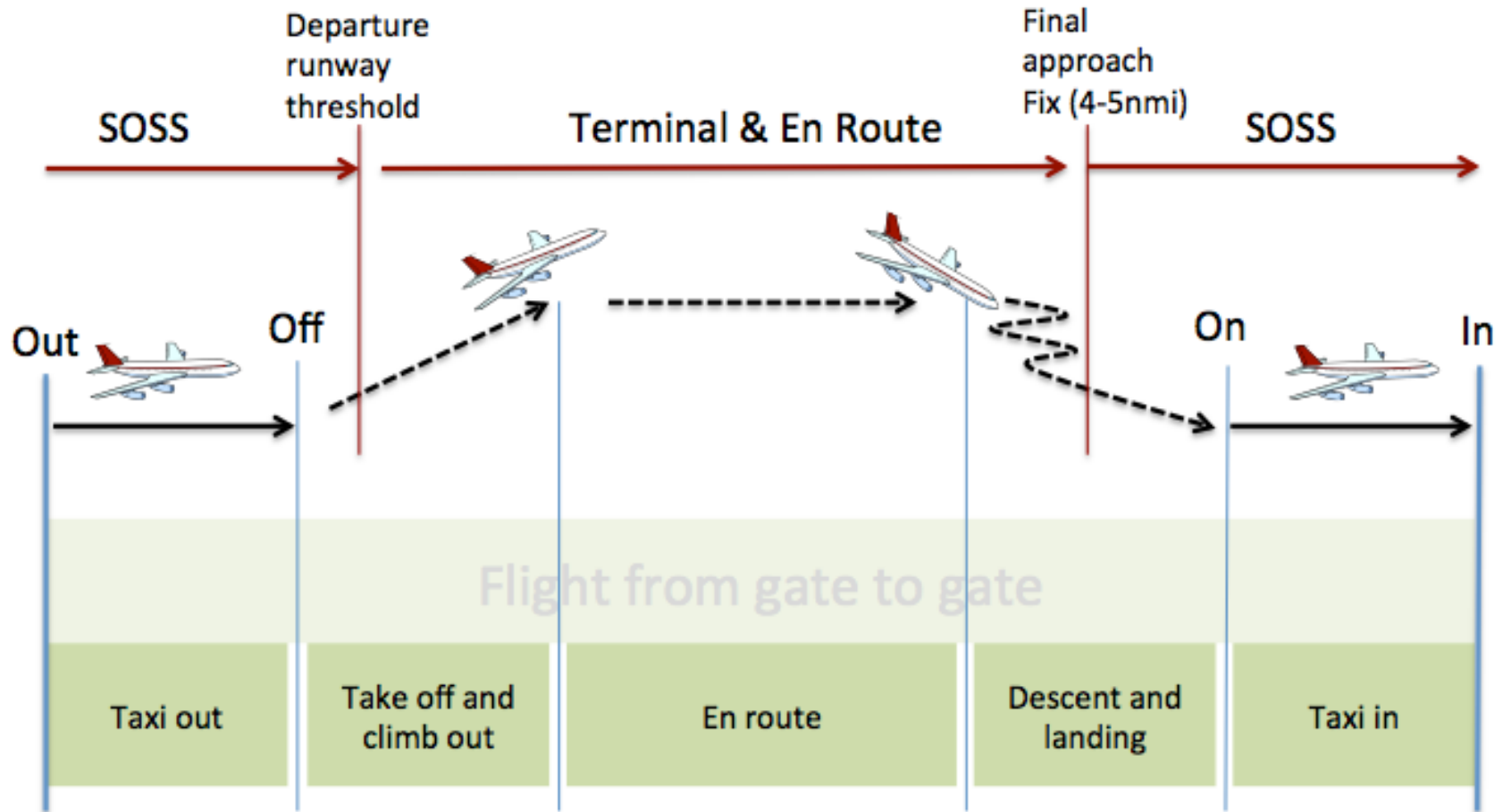
```
ARSLA40018642:bin zzhu2$ soss ../test/test_configuration_jfk.txt
sossApp initializing ...
SOSSApp::initialize(): ready at [9000.0, 0.5, 100x], Airport: JFK,
Scenario data: JFK_20090422_2hr.list_data
start simulation, wait ...
SOSSApp finished at [time, count] = [9000.00, 18000]
AircraftManager finished at [time, count] = [8999.50, 18000]
SchedulerManager finished at [time, count] = [8999.50, 18000]
simulation finished
saving raw data ... done
ARSLA40018642:bin zzhu2$
```

What is SOSS: Domain



- Fast time simulation tool running on desktop/laptop computer
- Manage surface and runway traffic

What is SOSS: Domain



What is SOSS: Airport Models



- Fast time simulation tool running on desktop/laptop computer
- Manage surface and runway traffic
- **Airport model independent**

What is SOSS: Airport Models



Surface Operation Simulator and Scheduler (SOSS) v2.130 [Simulation Mode]

File Edit View Preferences Tools Help Mode

Aircraft List

	Call Sign	AC Type	Category	P Time
1	VRD935	A320	Departure	10779
2	AAL1047	B738	Departure	11614
3	VRD469	A320	Arrival	38485
4	WJA1422	B738	Arrival	39210
5	VRD874	A319	Departure	05837
6	VRD406	A320	Departure	12173
7	VRD334	A320	Departure	11220
8	VRD399	A320	Arrival	36254
9	VRD363	A319	Arrival	36176
10	VRD321	A320	Arrival	32491
11	VRD1930	A320	Arrival	32868
12	VRD290	A320	Departure	05598
13	VRD312	A320	Departure	05400

ICN, north_flow, /scenario_data/ICN_scenario.1.list_data

Simulation time and FTG info Mouse Position: (32, 1174.76)

CLT, south_flow1, /scenario_data/CLT_20100720_2hr_v4.list_data

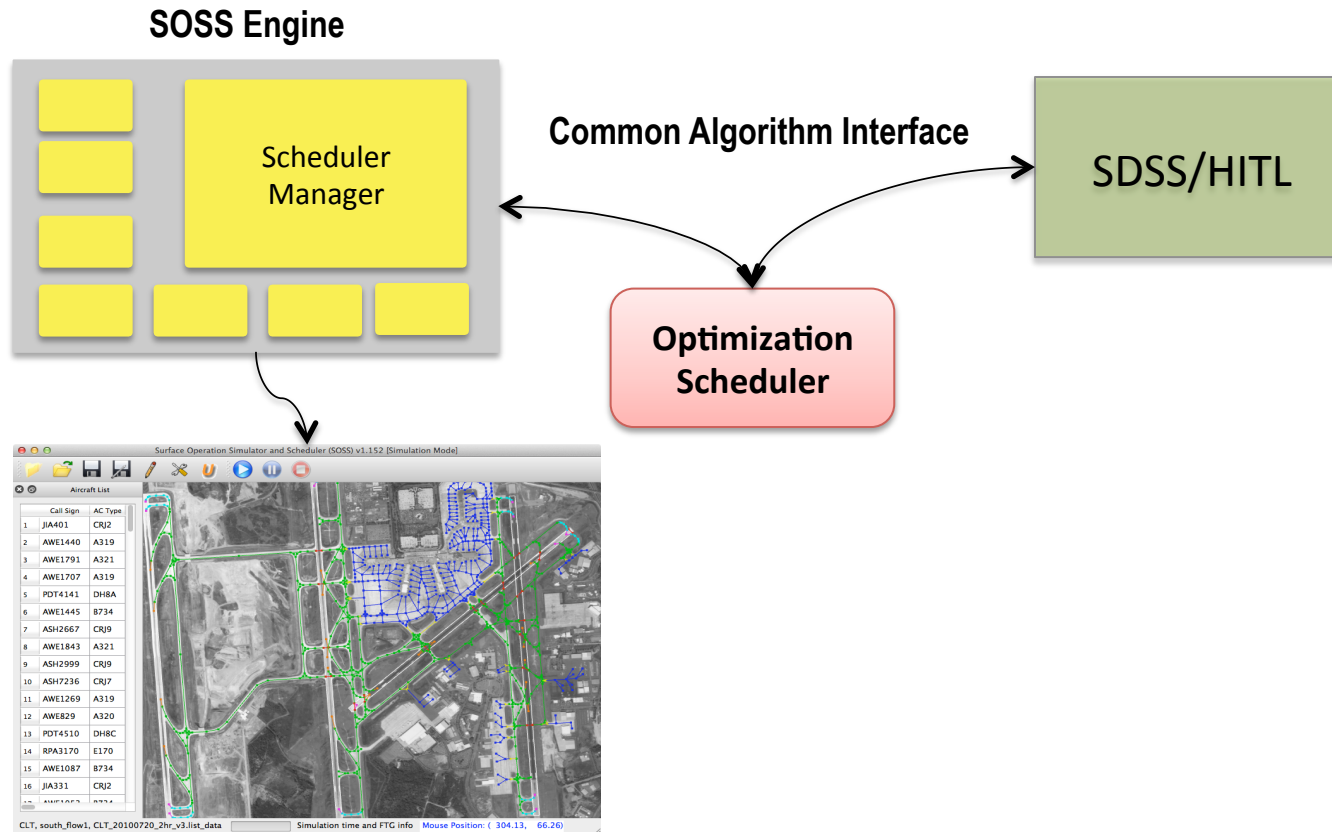
Simulation time and FTG info Mouse Position: (1405.50, -508.25)

What is SOSS: CAI Support



- Fast time simulation tool running on desktop/laptop computer
- Manage surface and runway traffic
- Airport model independent
- **Common interface to scheduling algorithms with human-in-the-loop (HITL) simulation**

What is SOSS: CAI Support

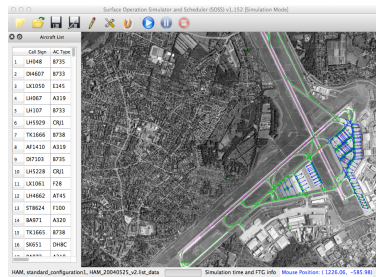


What is SOSS: Output



- Fast time simulation tool running on desktop/laptop computer
- Manage surface and runway traffic
- Airport model independent
- Common interface to scheduling algorithms with human-in-the-loop (HITL) simulation
- **Post data analysis on database**

What is SOSS: Output



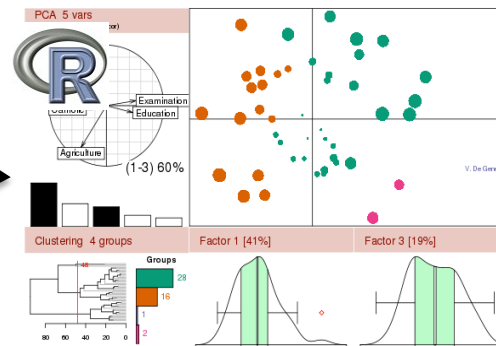
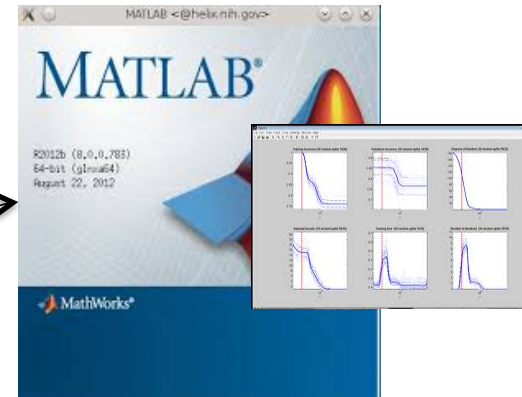
SQLite Database Browser - /Users/zzhu2/Desktop/Task 98/EDDH_Data/HAM_20040525_v2C...

Database Structure Browse Data Execute SQL

Table: ACScheduleDataTable

	acCalisign	acld	nodeId	nomSchedTime	actTimeArrival	actTimeRelease	STR
43	C91610	0	674	5769.91	5769.43	5769.43	
44	C91610	0	675	5784.82	5784.34	5784.34	
45	C91610	0	1175	5786.51	5786.03	5786.03	
46	C91610	0	607	5788.2	5787.72	5787.72	
47	C91610	0	606	5791.54	5791.06	5791.06	
48	C91610	0	605	5799.95	5799.46	5799.46	
49	C91610	0	604	5808.35	5807.87	5807.87	
50	C91610	0	1155	5810.94	5810.46	5810.46	
51	C91610	0	613	5813.53	5813.05	5813.05	
52	C91610	0	612	5820.75	5822.82	6722.82	
53	D17100	1	512	5863.0	5862.5	5862.5	
54	D17100	1	1207	5868.59	5868.1	5868.1	
55	D17100	1	646	5874.15	5873.66	5873.66	
56	D17100	1	1191	5876.83	5876.34	5876.34	
57	D17100	1	767	5879.51	5879.02	5879.02	
58	D17100	1	1190	5882.8	5882.31	5882.31	

< 1 - 1000 of 14667 > Go to: 0



What is SOSS: Playback



- Fast time simulation tool running on desktop/laptop computer
- Manage surface and runway traffic
- Airport model independent
- Common interface to scheduling algorithms with human-in-the-loop (HITL) simulation
- Post data analysis on database
- **DVR type playback**

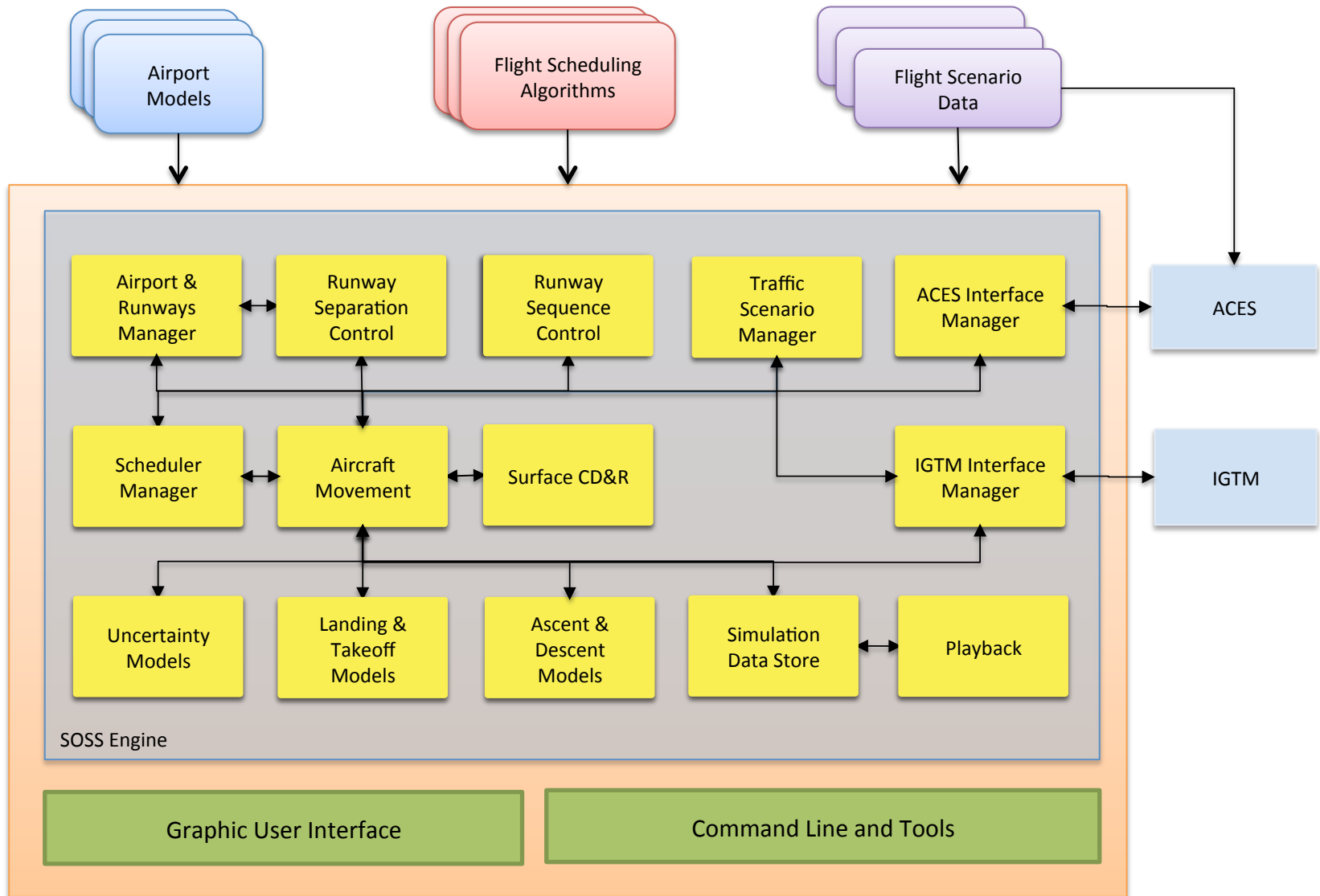
What is SOSS: Playback





- Different from HITL environment
 - No human interaction
 - Follow traffic scheduling advisories (best effort)
 - Can run various simulations in a short time
 - Useful for early prototype and adaptation for HITL modeling

SOSS System Architecture



How SOSS Models Airport Surface Traffic



- Airport adaptation
- Surface traffic movement
- Traffic scenarios
- Model integration
- Connection to scheduler
- Walk through example

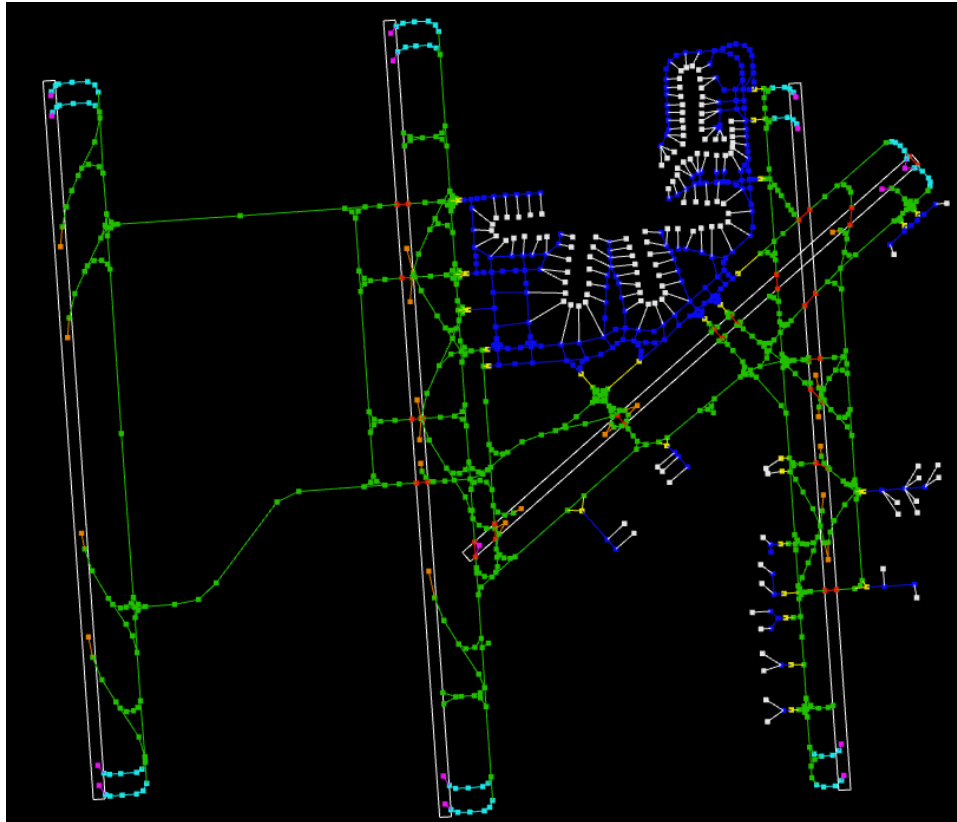


- Airport adaptation
 - Surface node-link graph
 - Runway configuration
 - Taxiing routes
 - Weather condition

How SOSS Models Airport Surface Traffic



- Airport adaptation
 - Surface node-link graph



Node-link graph representation of CLT

How SOSS Models Airport Surface Traffic

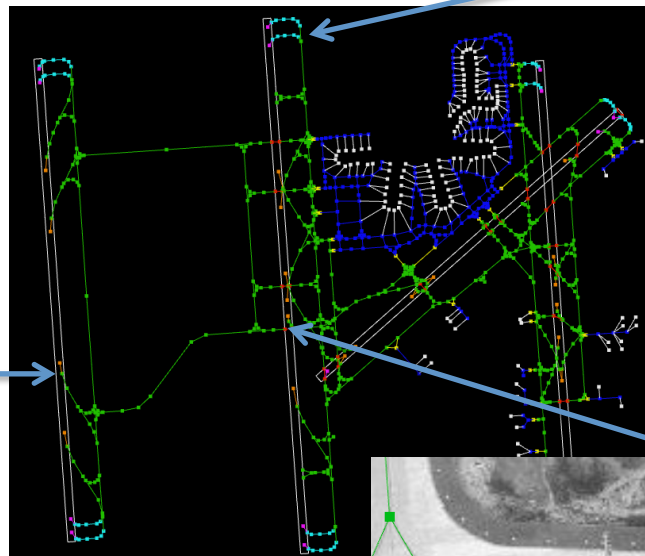
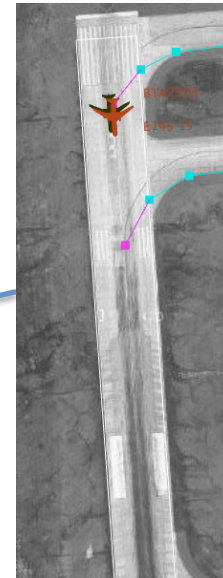


- Airport adaptation
 - Runway configuration
 - Runway geometry, length, heading
 - Takeoff, exit and crossings
 - Traffic flow direction
 - Runway separation rules

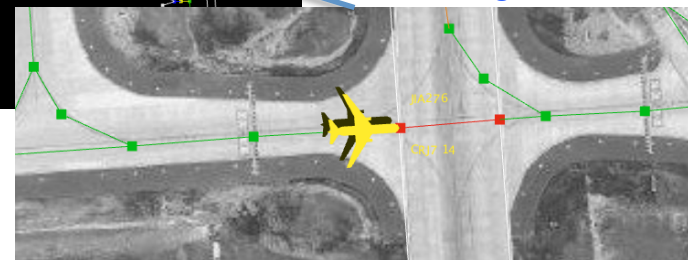
Runway exit



Takeoff position



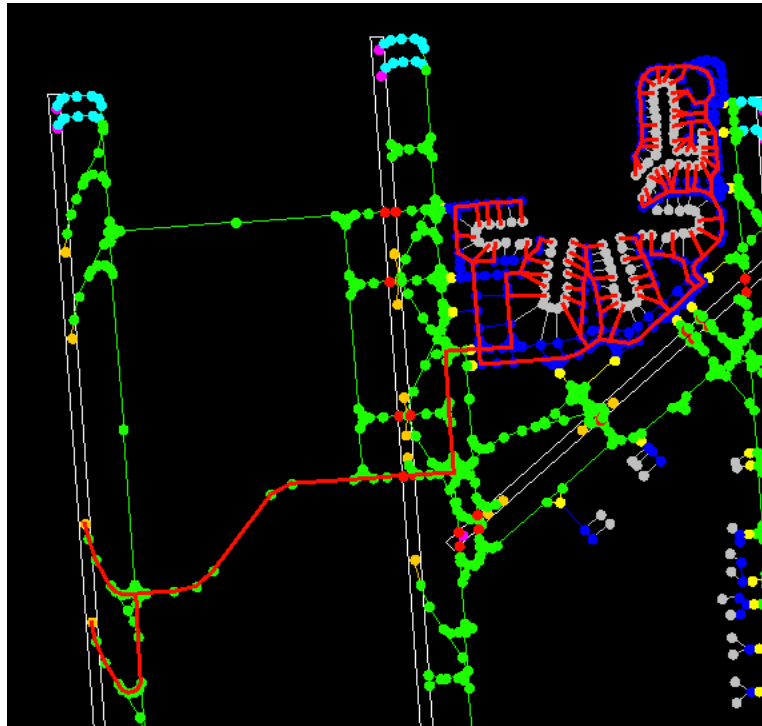
Crossing



How SOSS Models Airport Surface Traffic



- Airport adaptation
 - Taxiing routes
 - Based on surface operation configurations
 - Static taxiing routes between runways and gates
 - Multiple routes between runway and gate possible



How SOSS Models Airport Surface Traffic



- Airport adaptation
 - Weather condition
 - Currently only static wind (speed and direction) impacting on landing and takeoff

Weather Controls

Wind Direction (From Degrees)	<input type="text" value="150"/>	Wind Speed (Knots)	<input type="text" value="12"/>
----------------------------------	----------------------------------	-----------------------	---------------------------------



























- Airport adaptation
- Surface traffic movement
 - Built-in aircraft dynamics database
 - Aircraft taxiing mobility model
 - Separation criteria and surface conflict detection & resolution (CD&R)
 - Uncertainty model for taxi speed and flight readiness (i.e., pushback)

How SOSS Models Airport Surface Traffic



- Surface traffic movement
 - Built-in aircraft dynamics database
 - 459 aircraft types – extensible and substitution-able
 - Each type has 36 aircraft dynamic parameters
 - Weight class: small, large, heavy (, super heavy)

Properties	Statistics	Dependencies	Dependents	
Column	Owner	Comment		
 ModelType		Aircraft type		
 WeightClass		HEAVY, SMALL, LARGE		
 MaxClimbRate		ft/min?		
 MaxDescentRate		ft/min?		
 NumberOfEngines		engine quantity		
 EngineType		engine type: t, p, j		
 PseudoModel		used for pseudo control		
 MaxMach		mach		
 MinIAS		minimum air speed knots		
 MaxIAS		maximum air speed knots		
 MaxAlt		maximum altitude in feet		
 DefaultClimbSpeed		in knots		
 DefaultDescentSpeed		in knots		
 DefaultClimbMach		mach		
 DefaultDescentMach		mach		
 MaxTRACONSpeed		in knots, maximum speed th		
 MaxApprochSpeed		maximum approach speed in l		
 StraightInDistance		distance in nmi from touchdc		
 BaseLegDistance		in nmi from touchdown to a l		
 VERDecelDistance		in nmi		
 AircraftTypeName		this appears to be ac type na		
 MaxTaxiSpeed		knots		
 NormalTaxiSpeed		knots		
 ShallowTurnSpeed		knots		

Aircraft performance parameters

How SOSS Models Airport Surface Traffic



- Surface traffic movement
 - Aircraft taxiing mobility model
 - Aircraft type dependent mobility characteristics – speeds, accel/deccel
 - 'open-loop' movement with linear accel/decel and nominal speed
 - No turn/curve model yet
 - Taxi movement follows node-link along assigned route



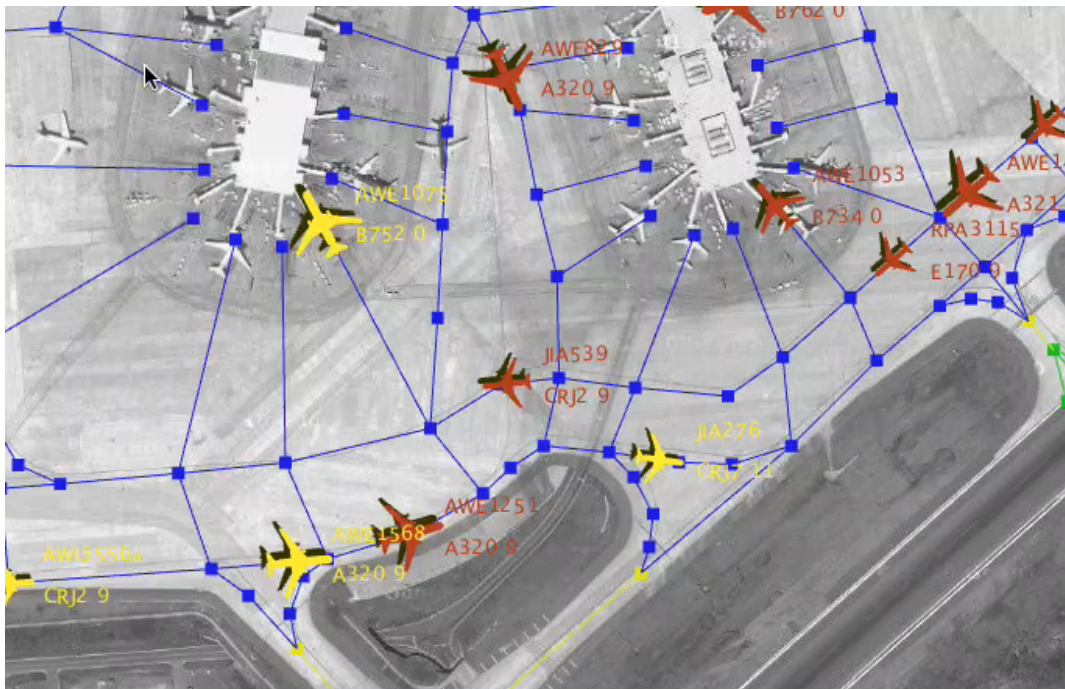
**Aircraft movement
from pushback to
takeoff**

How SOSS Models Airport Surface Traffic



- Surface traffic movement
 - Separation criteria and surface CD&R
 - Aircraft to aircraft safety separation
 - Conflict detection and FCFS resolution (localized)

Example of taxi separation and surface CD&R in the ramp area



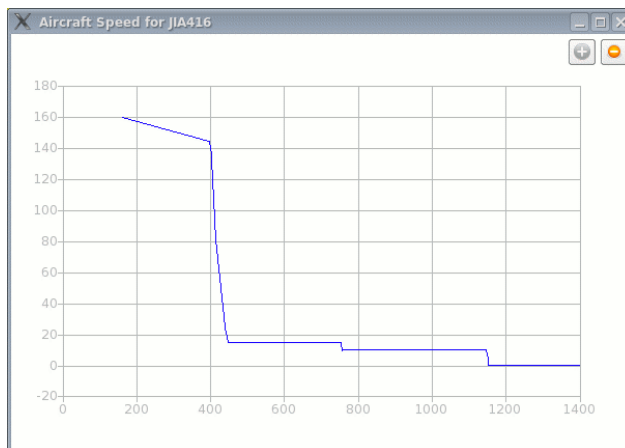
Aircraft movement
demonstrating
surface CD&R
capability

How SOSS Models Airport Surface Traffic

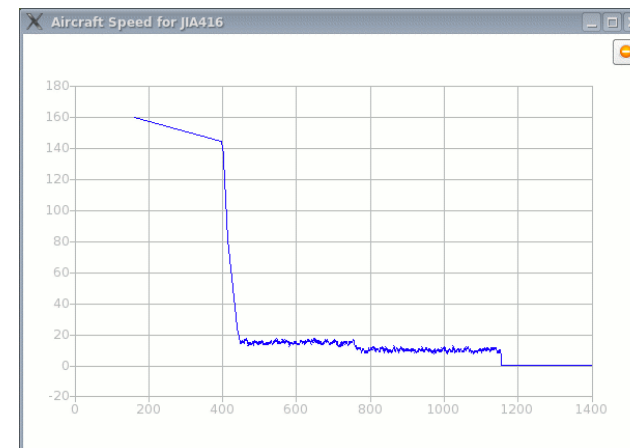


- Surface traffic movement
 - Uncertainty in speed and flight-readiness
 - Individual taxiing speed variation uncertainty
 - Individual flight readiness uncertainty

Uncertainty in flight readiness



No uncertainty in taxi speed



With uncertainty in taxi speed

How SOSS Models Airport Surface Traffic












- Airport adaptation
- Surface traffic movement
- **Traffic scenarios**
 - Static flight schedule scenario – surface only modeling
 - Dynamic flight schedule – terminal space integration

How SOSS Models Airport Surface Traffic



- Traffic scenarios
 - Static flight schedule scenario – surface only modeling
 - Flight ID, aircraft callsign, and aircraft type
 - Runway and gate assignment
 - Gate pushback time (or off block time)
 - Final approach start time
 - Destination airport
 - Tail number

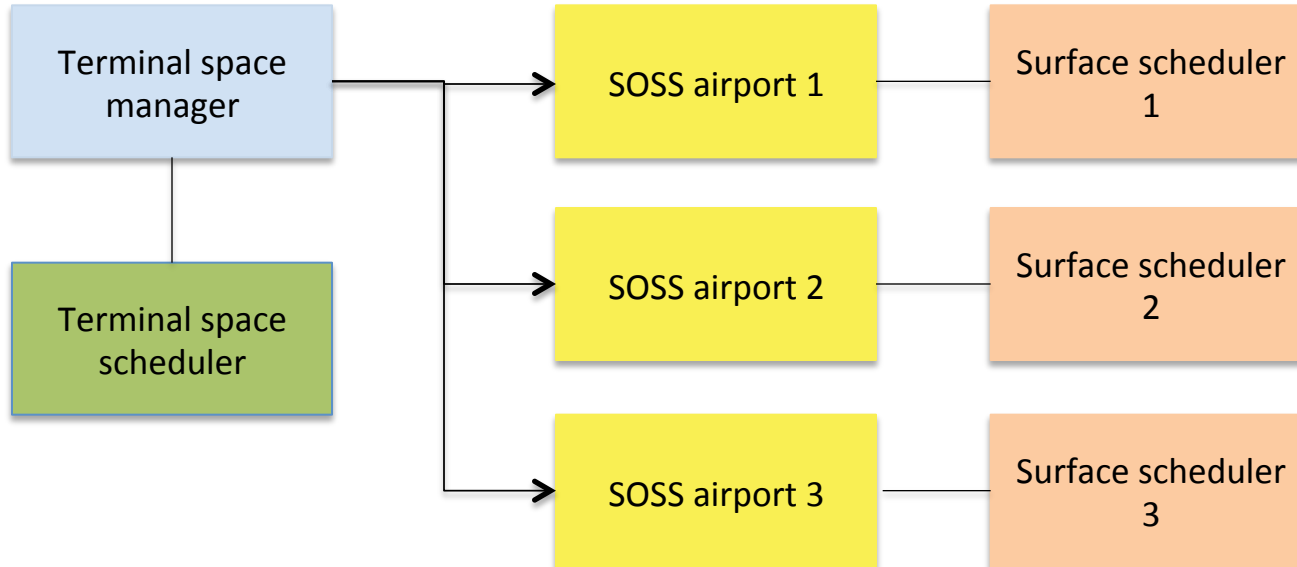
Column	Owner	Comment
 flight_id		unique flight id
 flight_type		inbound or outbound flight
 type		aircraft type that helps determine aircraft characteristics
 destination		destination airport for outbound flight
 runway		runway assignment
 position		usually the gate or stand position
 fix		metering fix
 tail		turnaround tail number
 time		flight schedule time may be wheel on, wheel off, gate off block or in block time

Data elements in traffic scenario

How SOSS Models Airport Surface Traffic



- Traffic scenarios
 - Dynamic flight schedule – terminal airspace integration
 - Allows runtime flight schedule passing to SOSS
 - SOSS handles inbound traffic to gate and handover outbound traffic to a terminal space flight manager
 - Support metroplex simulations



How SOSS Models Airport Surface Traffic



- Airport adaptation
- Surface traffic movement
- Traffic scenarios
- **Model integration**
 - Landing and takeoff models
 - Gate management model (a case study in 2015)
 - Other potentials (e.g., de-icing, fuel/emission model)

How SOSS Models Airport Surface Traffic



- Model integration
 - Landing and takeoff models – using aircraft dynamics, winds and runway configurations

Landing: runway threshold – wheels on – runway exit



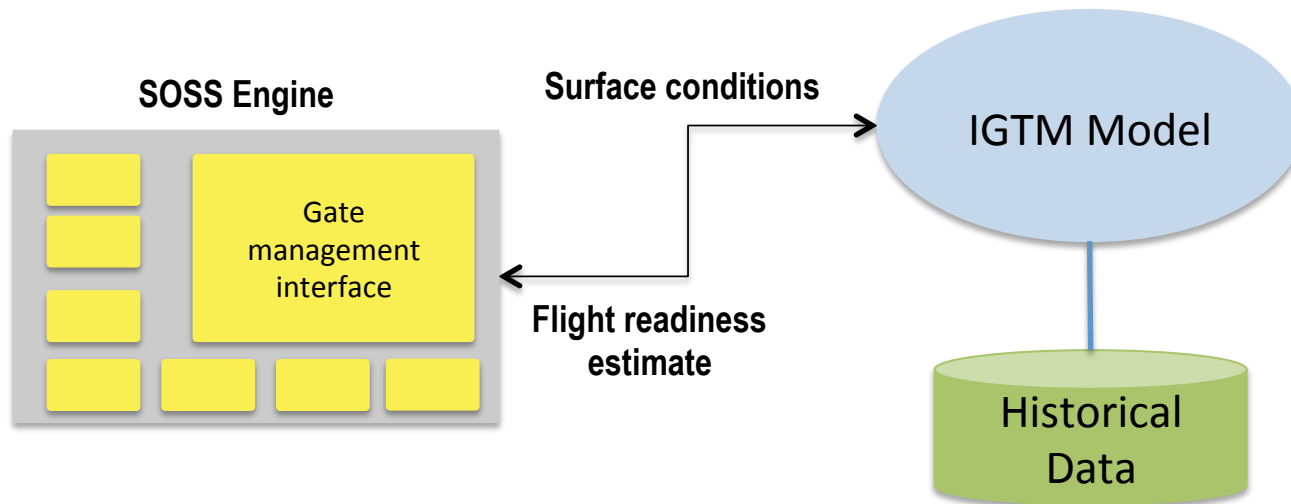
Takeoff: take off accel – wheels off – runway threshold



How SOSS Models Airport Surface Traffic



- Model integration
 - Landing and takeoff models
 - Gate management model (a case study tested in 2015)



How SOSS Models Airport Surface Traffic

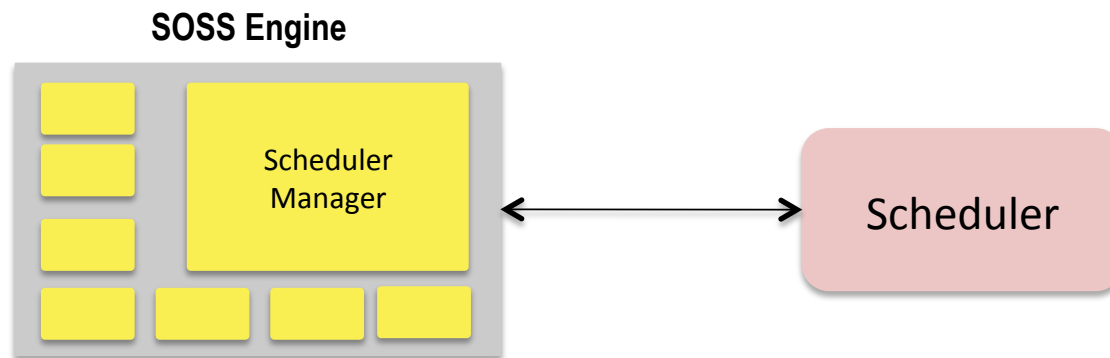


- Airport adaptation
- Surface traffic movement
- Traffic scenarios
- Model integration
- Connection to scheduler (e.g., SARDA scheduler)

How SOSS Models Airport Surface Traffic



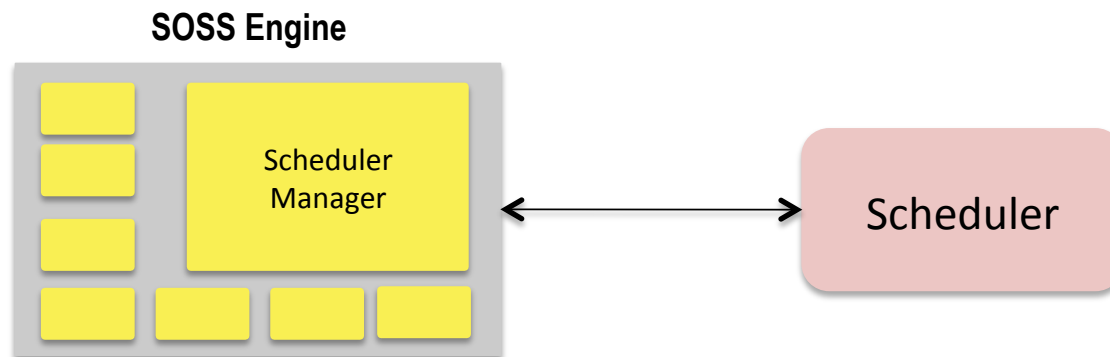
- Connection to scheduler
 - Communication between SOSS and a scheduling algorithm uses a Common Algorithm Interface (CAI) protocol
 - Scheduler call can be synchronized or a-synchronized
 - Multiple schedulers can be connected, e.g., one for each side runways



How SOSS Models Airport Surface Traffic



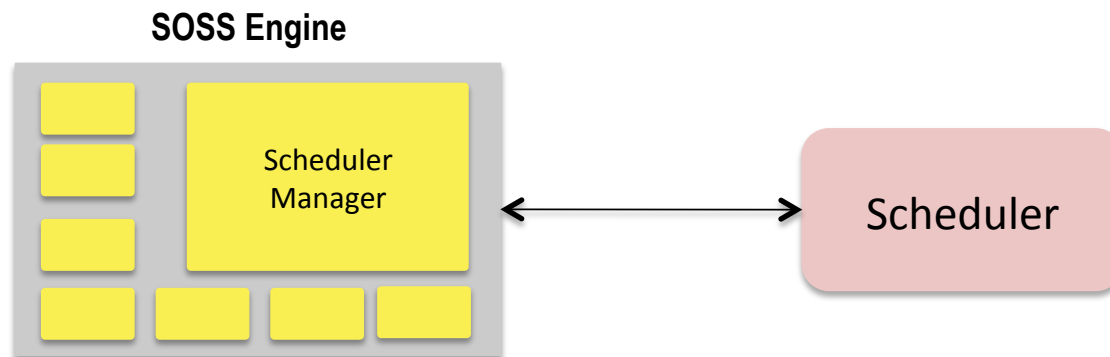
- SOSS to scheduler
 - Runway information: most recent operations (take off, landing, crossing)
 - Departure fix information: most recent fix usage (time, aircraft type, weight class)
 - List of aircraft in planning horizon: current states, predicted times, runway/gate, taxi routes



How SOSS Models Airport Surface Traffic



- Scheduler to SOSS
 - List of aircraft and STRs (scheduled time of release)
 - STRs can be provided at all nodes, but typically at control locations such as gate, spot, etc.
 - A branch of source code in SOSS distribution dedicated to building scheduler with the CAI is available



How SOSS Models Airport Surface Traffic



- Airport adaptation
- Surface traffic movement
- Traffic scenarios
- Model integration
- Connection to scheduler (e.g., SARDA scheduler)
- **Walk through example**



- Walk through example: departure without a scheduler
 - Initiate departure flights at assigned gates
 - Start push back at scheduled time
 - Follow the default taxi route to assigned runway
 - Aircraft joins traffic to runway queue
 - Enter runway queue in the order of arrival
 - Ready to take off and meet separation rules
 - Takeoff model takes over
 - Runway events (start acceleration, wheels off, threshold crossing) are registered

Build SOSS ICN model



- Build a SOSS ICN model, step by step

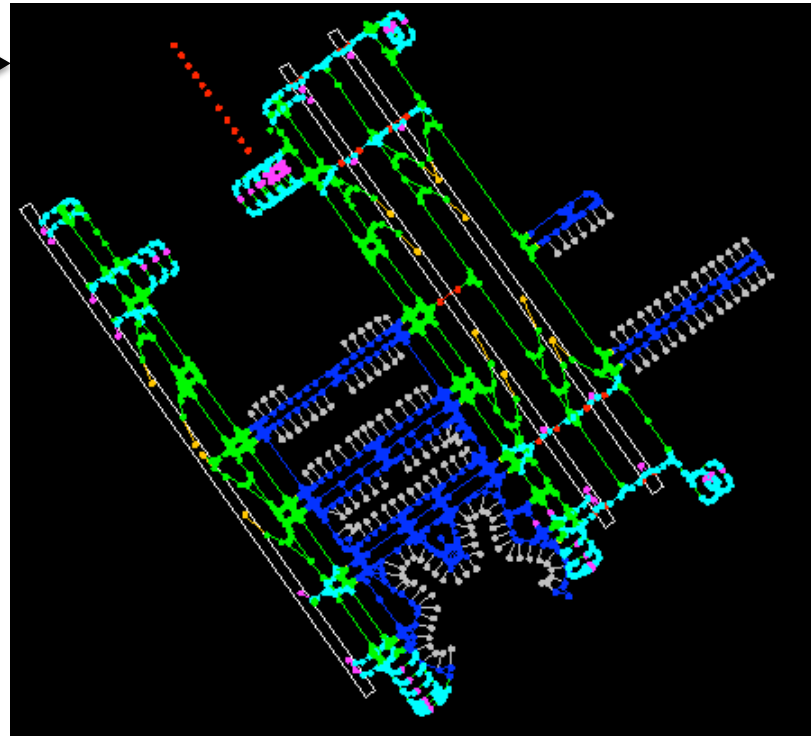
Operation Info & historical
data

Build SOSS ICN model



- Build a SOSS ICN model, step by step

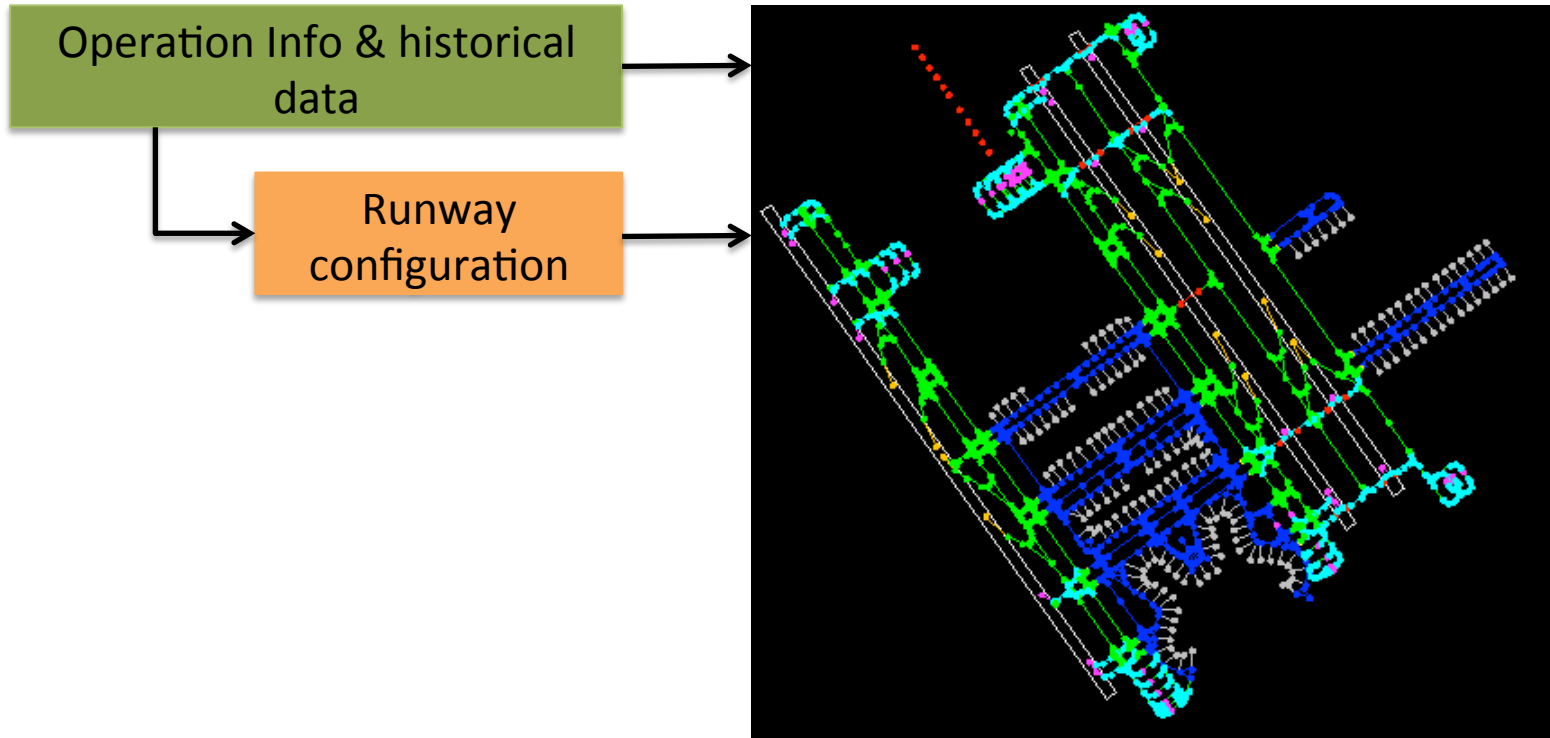
Operation Info & historical
data



Build SOSS ICN model



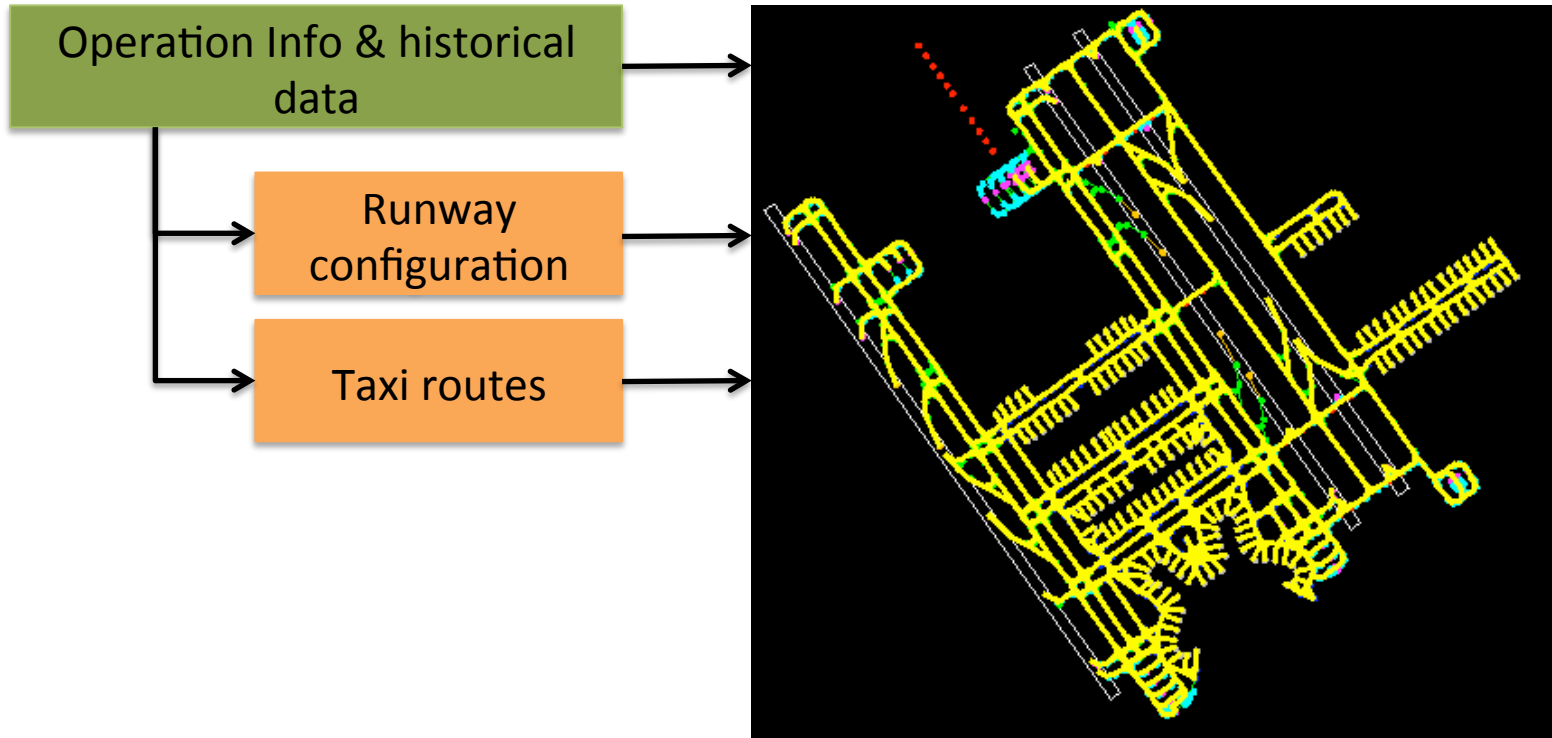
- Build a SOSS ICN model, step by step



Build SOSS ICN model



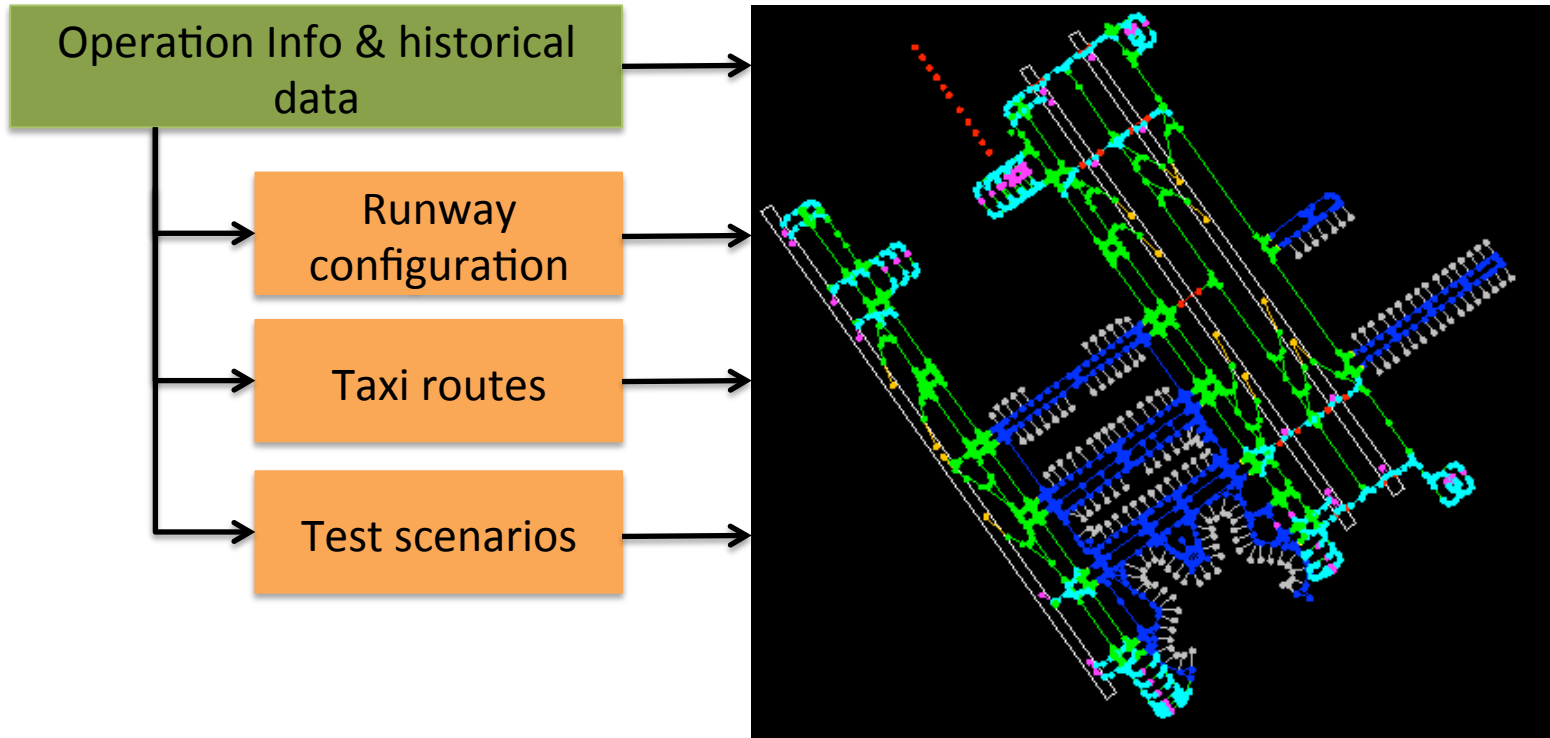
- Build a SOSS ICN model, step by step



Build SOSS ICN model



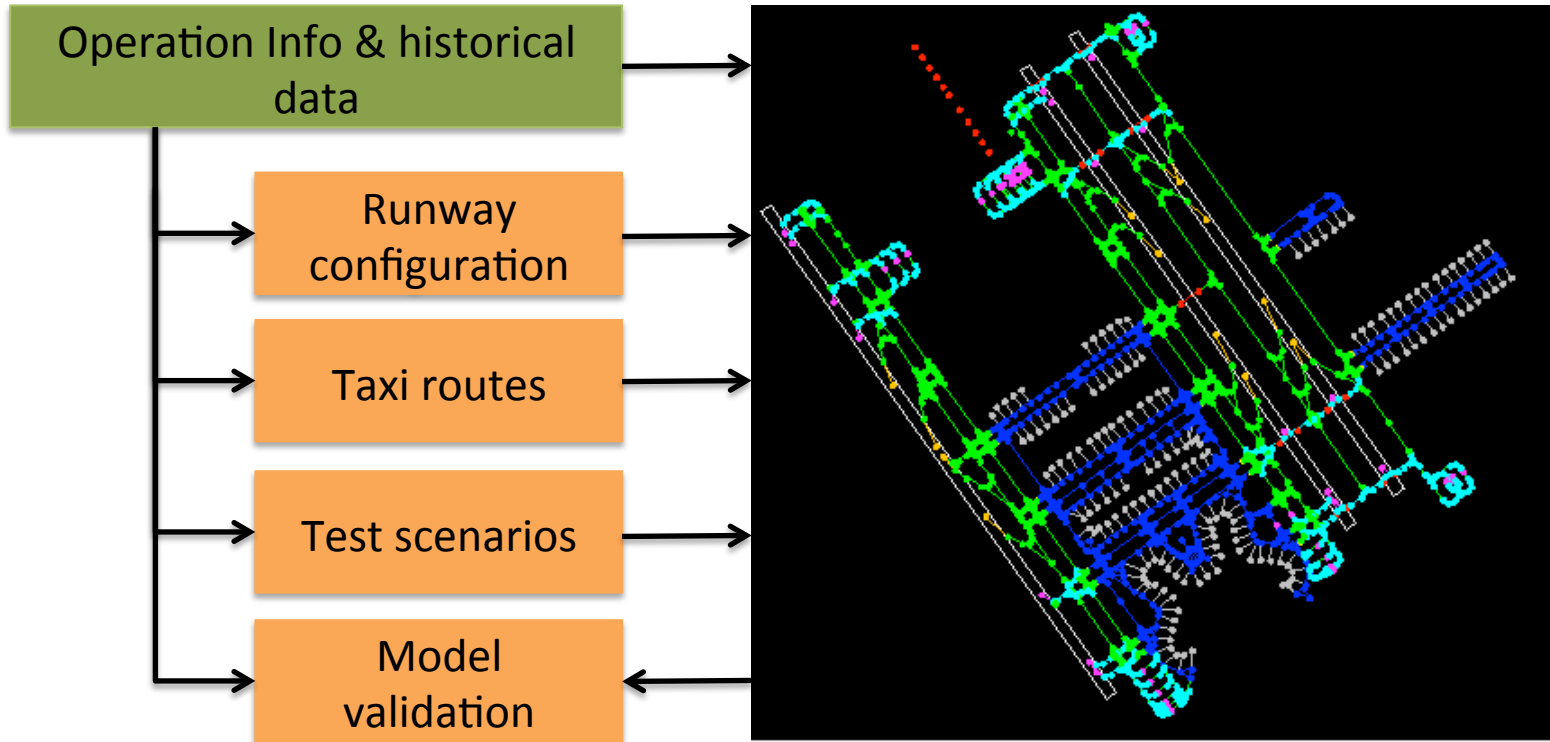
- Build a SOSS ICN model, step by step



Build SOSS ICN model



- Build a SOSS ICN model, step by step



Summary



- SOSS is a fast-time surface traffic modeling and simulation tool for desktop/laptop computer
- Allow building of airport adaptation model, shared with HITL simulation environment
- Use the same interface (i.e., CAI) to surface scheduling algorithm as the real-time environment
- Help build early prototype decision support tools and evaluation of scheduling algorithms
- Has a modular architecture for model/component integration
- Provide a complement surface modeling and simulation capability to HITL simulation

Questions?

